Chapter 13

Foot: Tarsals, Metatarsals, and Phalanges

The bones of the foot are obvious serial homologs of the hand bones. The deep evolutionary history of foot elements is similar to that described for those of the hand in Chapter 10. There are a total of 26 bones in each human foot, one less than in each hand. Of the seven tarsal bones, two occupy a proximal row, four occupy a distal row, and one is centered between rows. The tarsals are followed distally by a single row of five metatarsals. Farther distally, there is a single row of five proximal phalanges, a single row of four intermediate phalanges, and a single row of five distal, or terminal, phalanges.

In addition to these 26, as with the hand, there are small sesamoid bones that lie within tendons of the foot. In the foot, a pair of sesamoids is usually found below the head of the first metatarsal. Figures 13.1–13.5 summarize and illustrate articulations within the foot. Elements of the foot skeleton can be divided into three segments: the **tarsals**, **metatarsals**, and **phalanges**.

It is convenient to apply specific directional terms to the foot. **Plantar** refers to the sole of the foot, its inferior surface in standard anatomical position. **Dorsal** is the opposite surface, superior in humans. **Proximal** (posterior) is toward the tibia, **distal** (anterior) is toward the toe tips, and the distalmost phalanges are referred to as "terminal." In addition, the big toe is sometimes called the **hallux**, and its ray is identified as ray 1. Other rays are numbered as in the hand.

The human foot has changed dramatically during its evolution from a grasping organ to a structure adapted to bipedal locomotion. Most of the mobility, flexibility, and grasping abilities of the foot have been lost in humans as the foot adapted to shock absorption and propulsion.

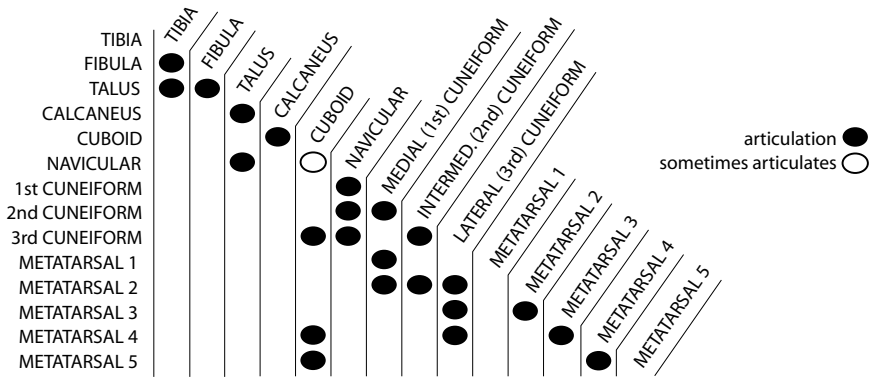

Figure 13.1 **Articulation of bones in the adult human ankle and foot.**

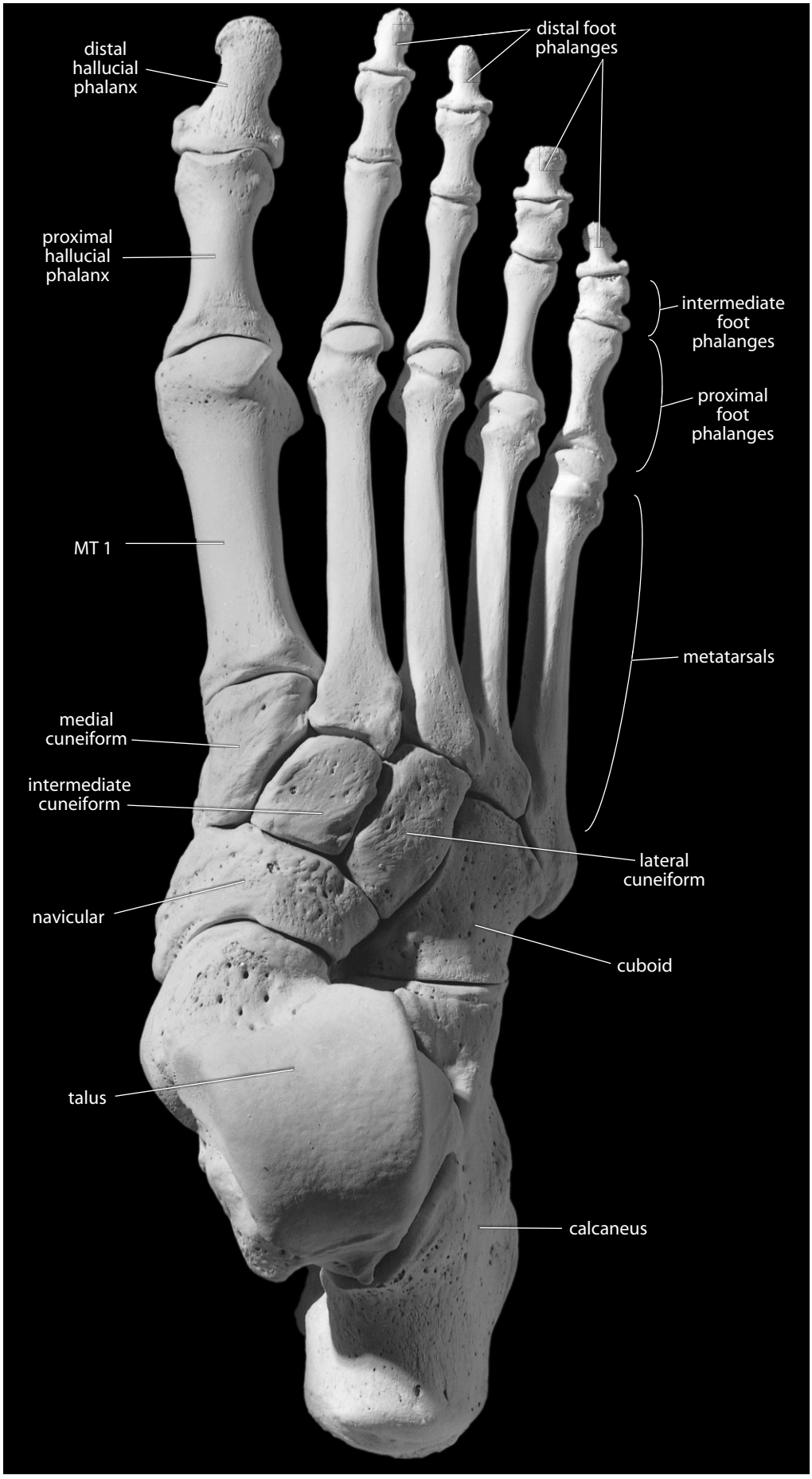

Figure 13.2 **Right foot, dorsal (superior).** Sesamoid bones not included. Natural size.

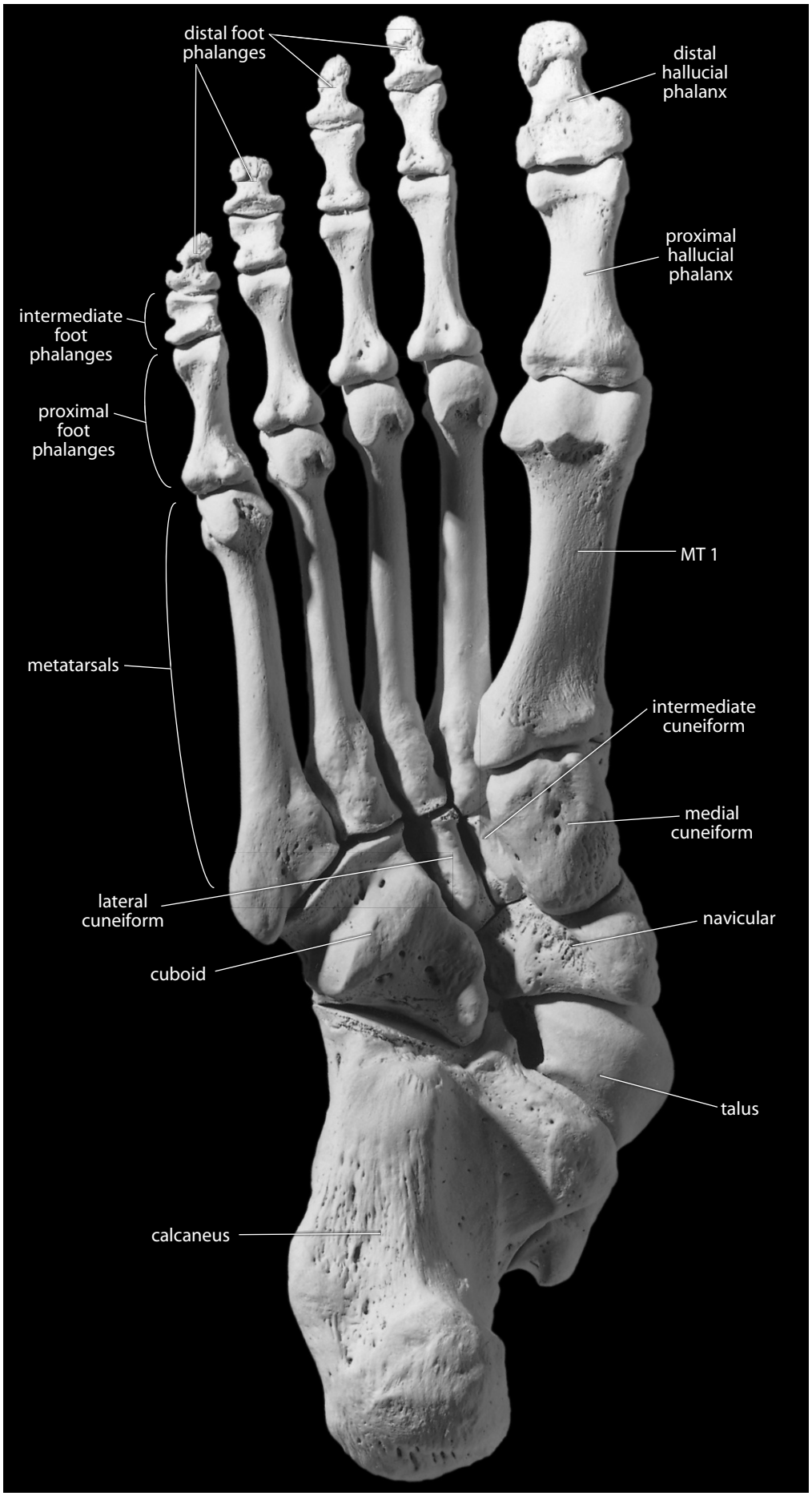

Figure 13.3 **Right foot, plantar (inferior)**. Sesamoid bones not included. Natural size.

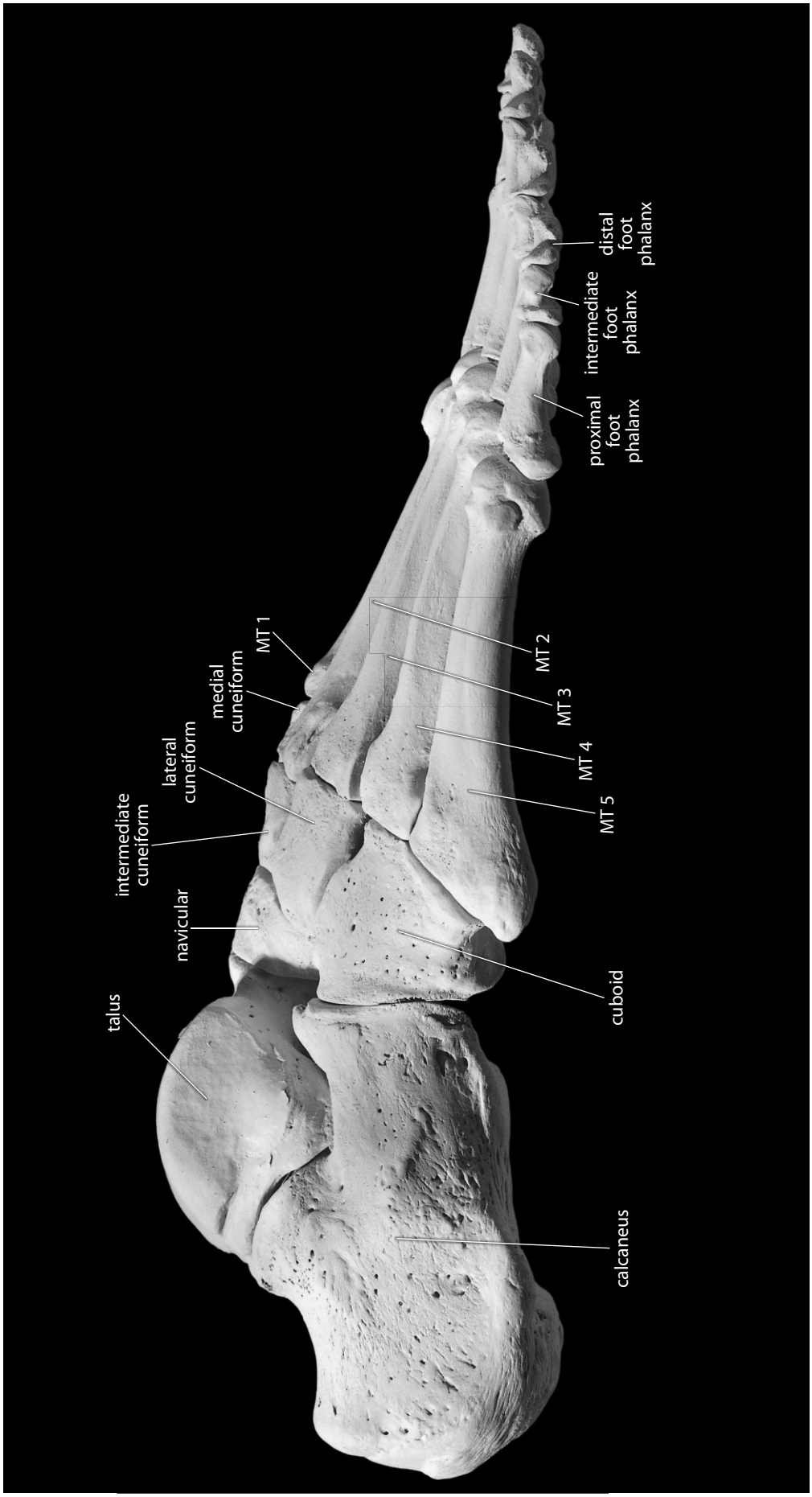

Figure 13.4 **Right foot.** Lateral view. Natural size.

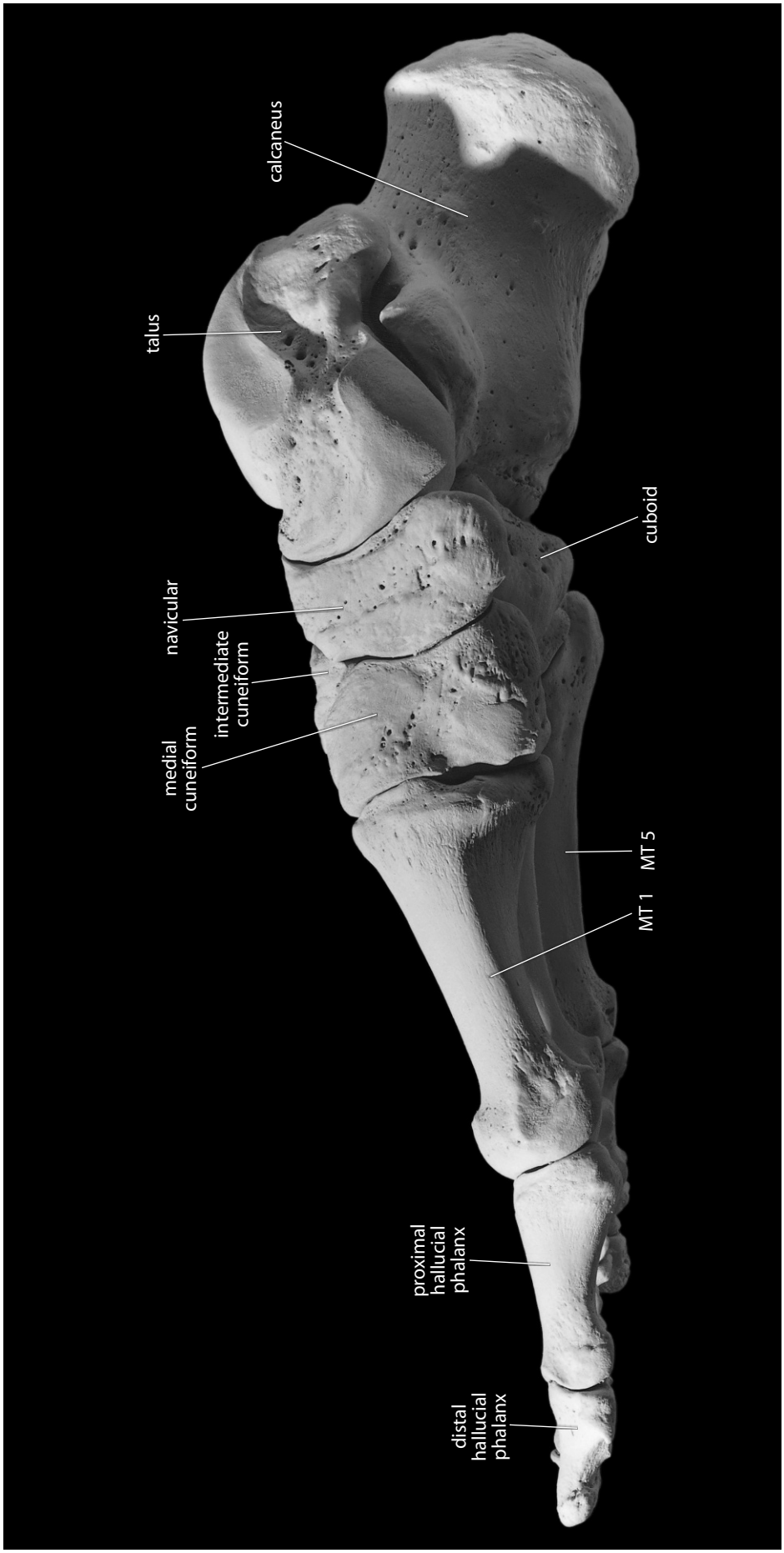

Figure 13.5 **Right foot.** Medial view. Sesamoid bones not included. Natural size.

13.1 Tarsals

The seven tarsals combine with the five metatarsals to form the longitudinal and transverse arches of the foot. The **talus** articulates superiorly with the distal tibia and fibula at the ankle joint. The **calcaneus** forms the heel of the foot, supports the talus, and articulates anteriorly with the **cuboid**, the third largest tarsal bone. The metatarsals articulate proximally with the cuboid and three **cuneiforms**. The seventh tarsal, the **navicular**, is interposed between the head of the talus and these cuneiforms.

13.1.1 Talus (Figures 13.6–13.7, 13.17)

The talus is called the **astragalus** in other animals. It is the second largest of the tarsals and is situated between the tibia and fibula superiorly and the calcaneus inferiorly. No muscles attach to this bone. It rests atop the calcaneus and articulates distally with the navicular. It forms the lower member of the **talocrural joint**. Talar variation is illustrated in Figure 3.1 of Chapter 3.

a. The **head** is the rounded, convex, distal articular surface of the talus. It fits into the hollow of the navicular.
b. The **body** is the squarish bulk of the bone posterior to the talar neck.
c. The **trochlea** is the saddle-shaped articular surface of the body. Its sides are the **lateral** and **medial malleolar surfaces** (or **facets**), which articulate with the fibula and tibia, respectively.
d. The **neck** connects the head of the talus to the body. Occasionally there are small articular facets on the neck, formed by contact with the anterior surface of the distal tibia during strong dorsiflexion of the foot at the ankle (or talocrural) joint. These facets are called squatting facets.

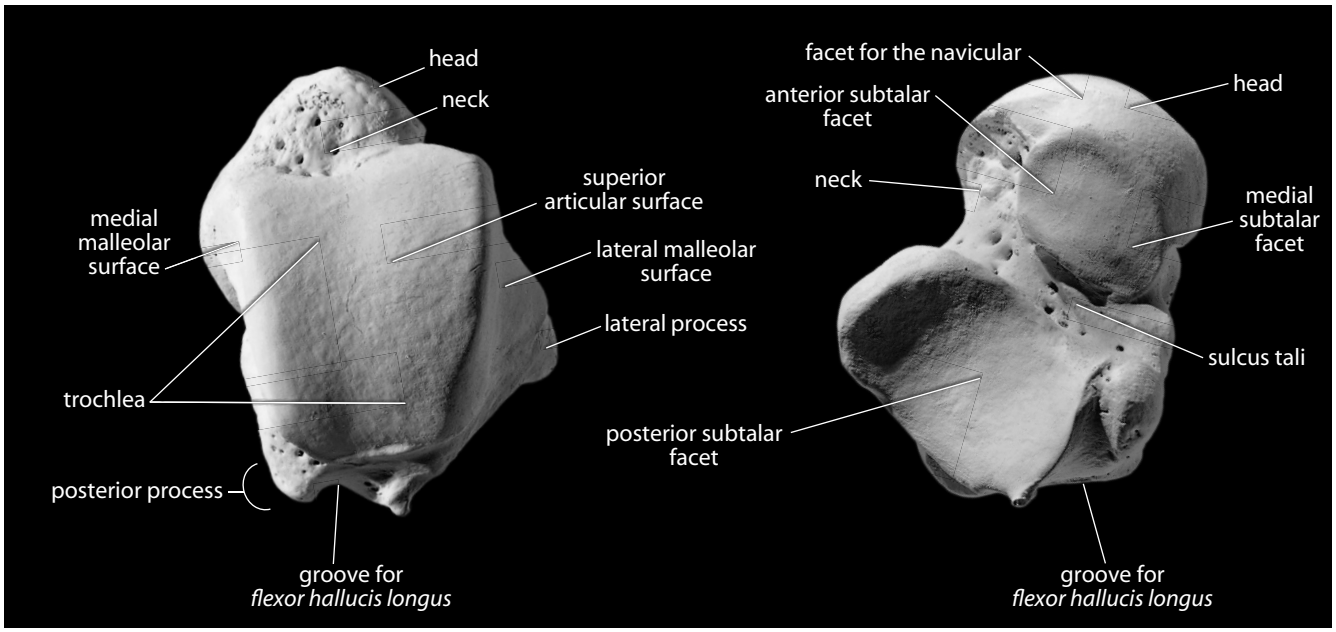

Figure 13.6 **Right talus.** *Left:* dorsal (or superior) view; *right:* plantar (or inferior) view. Distal is up. Natural size.

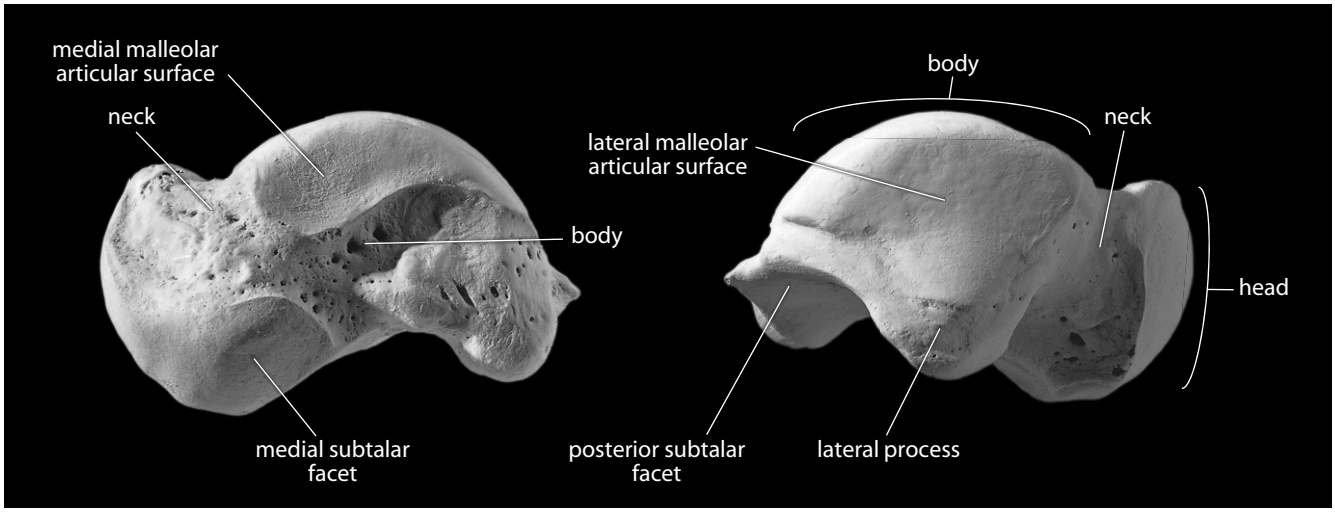

Figure 13.7 **Right talus.** *Left:* medial view; *right:* lateral view. Dorsal is up. Natural size.

e. The **groove for *flexor hallucis longus*** is the short, nearly vertical groove on the posterior surface of the talar body. It is so named because it transmits the tendon of this muscle, a calf muscle that plantarflexes the foot and hallux.

f. The **subtalar** (or **calcaneal**) **facets** on the inferior aspect of the talus are usually three in number and variable in shape.

   1. The **anterior subtalar** (or **calcaneal**) **facet** is the most anterior facet on the plantar (inferior) surface of the talus, often somewhat continuous with the articular surface of the talar head.
   2. The **medial subtalar** (or **calcaneal**) **facet** is highly variable, sometimes separated from — but often merging to a greater or lesser extent with — the anterior subtalar facet (see Figure 3.1 for examples).
   3. The **posterior subtalar** (or **calcaneal**) **facet** is the largest facet on the plantar surface of the talus. It is concave and obliquely oriented (posteromedial to anterolateral).

g. The **sulcus tali** is the deep groove between the posterior and middle subtalar facets.

- **Anatomical siding:** The saddle-shaped articular surface for the distal tibia is superior, and the talar head is anterior. The larger malleolar surface (for the fibula) is lateral.
- **Positional siding:** The head is medial when viewed from above and aligns with the hallux.

13.1.2 Calcaneus (Figures 13.8–13.10, 13.17)

The calcaneus, or "heel bone," is the largest of the tarsal bones and the largest bone of the foot. It is located inferior to the talus and articulates anteriorly (distally) with the cuboid.

a. The **calcaneal tuberosity** is the large, blunt, nonarticular, posterior process of the heel. It is the insertion point of the *calcaneal* (or *Achilles*) *tendon*. Contraction of the *gastrocnemius* and *soleus muscles* of the calf causes plantarflexion of the foot, with the calcaneal tuber serving as a lever arm that uses the talar body as its fulcrum.

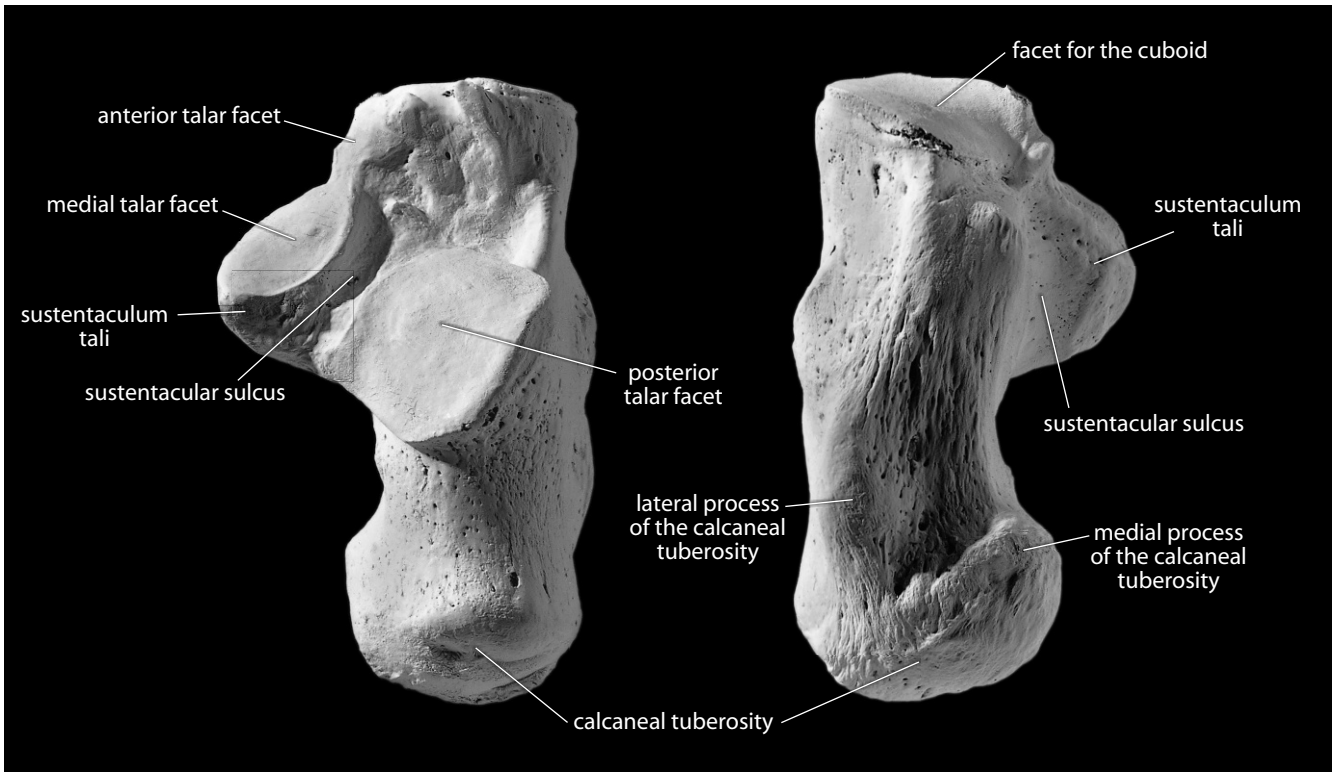

Figure 13.8 **Right calcaneus.** *Left:* dorsal (or superior) view; *right:* plantar (or inferior) view. Distal is up. Natural size.

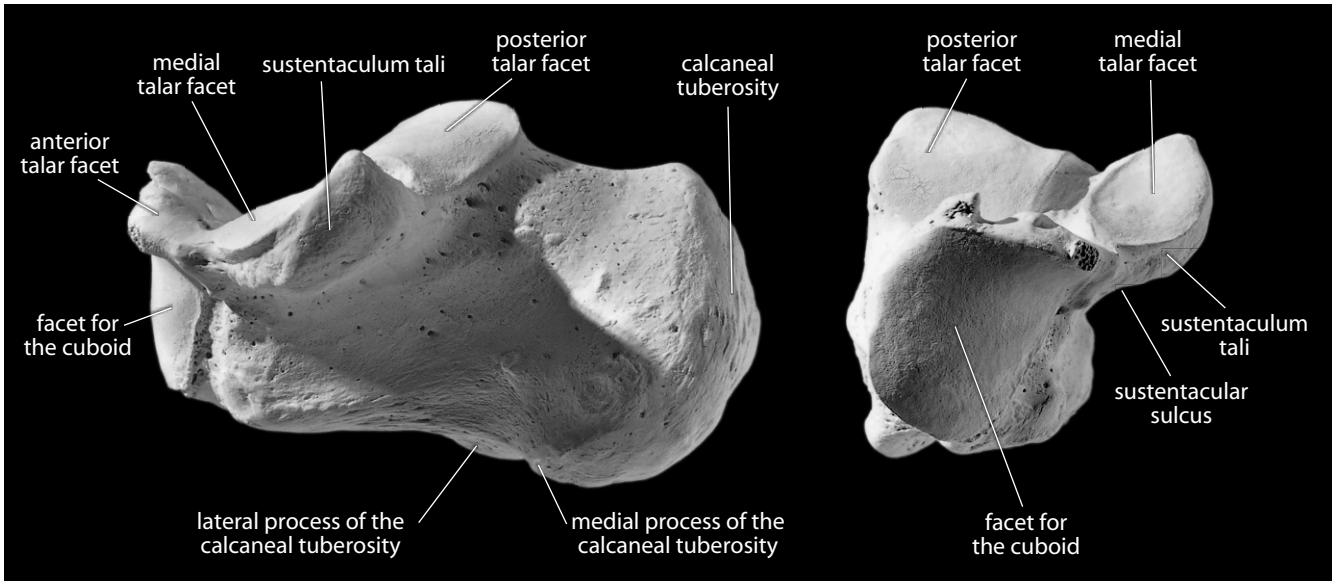

Figure 13.9 **Right calcaneus.** *Left:* medial view; *right:* anterior view. Dorsal is up. Natural size.

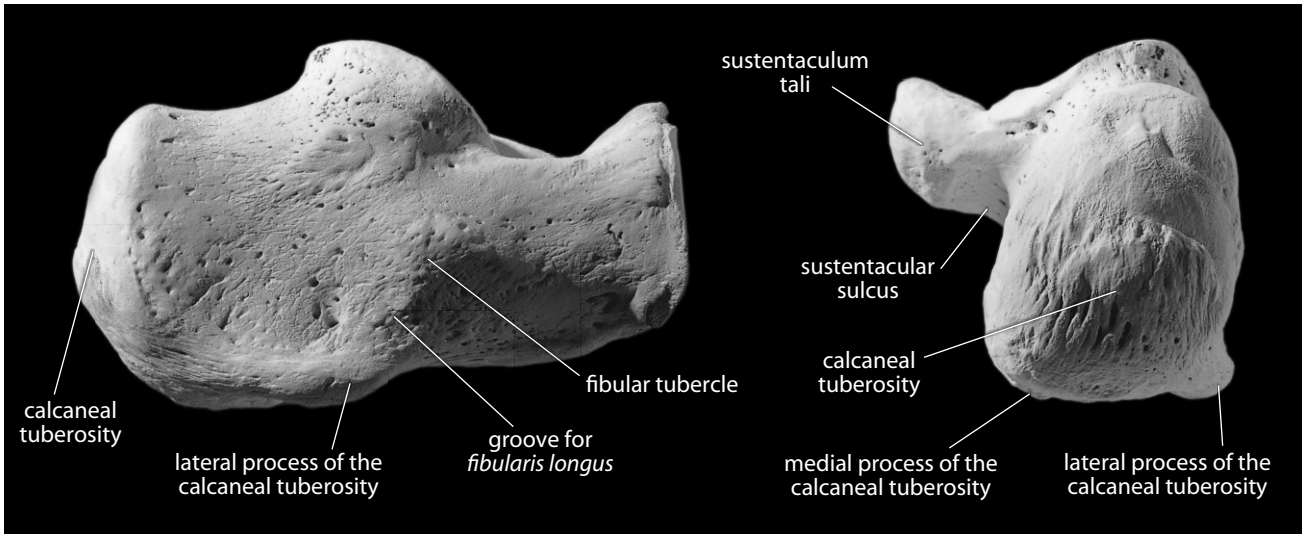

Figure 13.10 **Right calcaneus.** *Left:* lateral view; *right:* posterior view. Dorsal is up. Natural size.

b. The **lateral** and **medial processes**, on the plantar portion of the calcaneal tuberosity, serve to anchor several *intrinsic muscles* of the foot. The lateral process is much smaller than the medial.

c. The **sustentaculum tali** is the shelf on the medial side of the calcaneus. It supports the talar head.

d. The **sustentacular sulcus** (or **groove**), just inferior to the sustentaculum, is a pronounced groove. The *tendon of the flexor hallucis longus muscle*, a plantarflexor of the big toe, travels through this groove. It is continuous posterosuperiorly with the groove on the posterior extremity of the talus.

e. The **fibular tubercle** is a rounded projection low on the lateral surface of the calcaneal body. It is closely associated with *tendons of the fibularis (peroneus) longus* and *brevis muscles*. These muscles plantarflex and evert the foot, inserting on the base of the first and fifth metatarsals, respectively.

f. The **groove** (or **sulcus**) **for *fibularis (peroneus) longus*** is located immediately inferior to the fibular tubercle.

- **Possible confusion:** It is not possible to confuse an intact calcaneus with another bone. A broken calcaneal body might sometimes be mistaken for a section of femoral greater trochanter, but the only articular surface on the proximal femur is the spherical head.
- **Anatomical siding:** The tuberosity is posterior, and the inferior surface is nonarticular. The sustentaculum tali projects medially, inferior to the talar head.
- **Positional siding:** With the heel away from you and the articular surfaces up, the shelf projects to the side from which the bone comes.

13.1.3 Cuboid (Figures 13.11–13.12)

The cuboid bone sits on the lateral side of the foot, sandwiched between the calcaneus and the fourth and fifth metatarsals, articulating with the navicular and third cuneiform. It is recognized by its large size and projecting, pointed, proximal articular surface. It is the most cuboidal, or cube-shaped, of the tarsal bones.

a. The **cuboid tuberosity** (Figure 13.12) is a large tuberosity on the inferolateral surface of the bone.
b. The *tendon for the fibularis (peroneus) longus muscle* enters the foot via the **groove** adjacent to this tuberosity.

- **Anatomical siding:** The wide, flat nonarticular surface is superolateral, and the pointed calcaneal facet is proximal. The tuberosity is inferolateral. There is an articulation on the medial, but not on the lateral surface.
- **Positional siding:** Look directly at the flat nonarticular surface. With the calcaneal facet toward you, the tuberosity projects laterally on the side from which the bone comes.

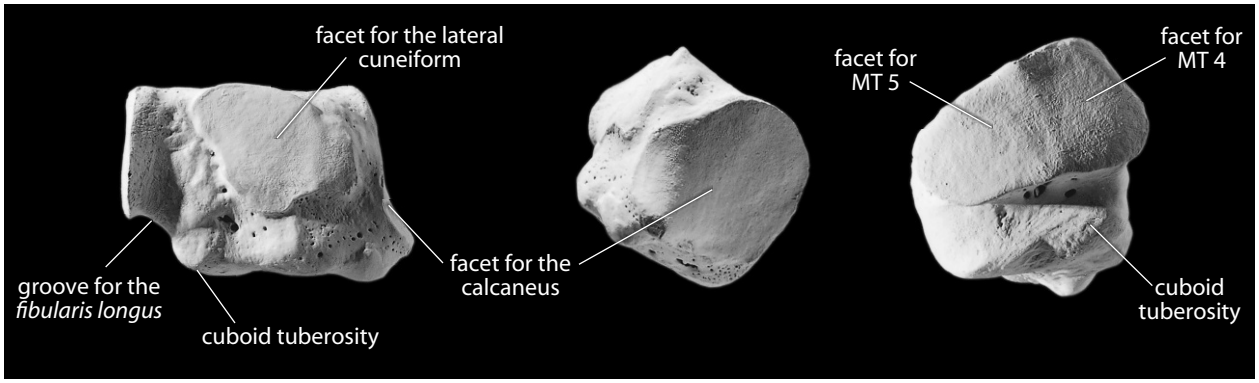

Figure 13.11 **Right cuboid.** *Left:* lateral view; *middle:* proximal view; *right:* distal view. Dorsal is up. Natural size.

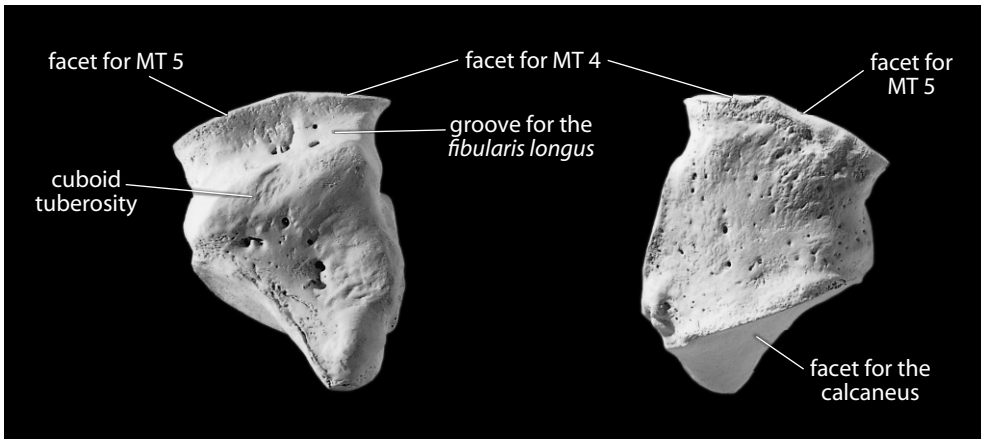

Figure 13.12 **Right cuboid.** *Left:* plantar (or inferior) view; *right:* dorsal (superior) view. Distal is up. Natural size.

13.1.4 Navicular (Figure 13.13)

The navicular is named for the strongly concave proximal surface that articulates with the head of the talus. On the distal surface, the navicular has a large facet divided by two ridges. These demarcate the articular planes of the three cuneiforms. In addition, the navicular often articulates with a corner of the cuboid.

a. The **tubercle** (Figure 13.13) of the navicular is a large, blunt projection on the medial side of the bone. This tubercle is the main insertion of the *tibialis posterior muscle*, a plantarflexor of the foot and toes.

- **Possible confusion:** Although generally similar in gross shape, this bone is much larger than the scaphoid and has a flat side with three facets.
- **Anatomical siding:** The concave talar facet is proximal. The large, flat nonarticular surface is dorsal, and the tubercle is medial.
- **Positional siding:** Hold the bone by the base of the tubercle, with the concave articular surface facing you and the flat nonarticular side up. The tip of the tubercle points toward the side from which the bone comes.

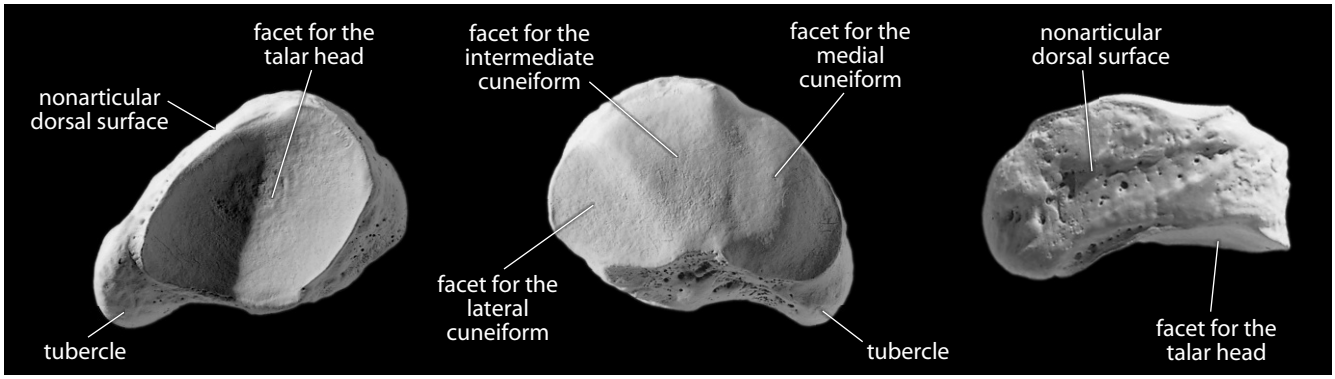

Figure 13.13 **Right navicular.** *Left:* proximal view, dorsal is up; *middle:* distal view, dorsal is up; *right:* superomedial view, distal is up. Natural size.

13.1.5 Medial (First) Cuneiform (Figure 13.14)

The medial cuneiform is the largest of three cuneiforms. It sits between the navicular and the base of the first metatarsal, articulating with these as well as with the second cuneiform and the base of the second metatarsal (MT 2). It is less wedge-shaped than the other cuneiforms and is distinguished by the kidney-shaped facet for the base of the first metatarsal.

- **Anatomical siding:** The longest, kidney-shaped articular surface is distal, its long axis vertical. The broad, rough, nonarticular surface is medial, and the lateral facet for the intermediate cuneiform is superior. The proximal facet for the navicular is concave.
- **Positional siding:** Place the large, kidney-shaped articular facet away from you and orient its long axis vertically, with the smaller, more concave navicular facet toward you. With the bone resting on its blunter end, the only other facet is near the top (superolateral) and faces toward the side from which the bone comes.

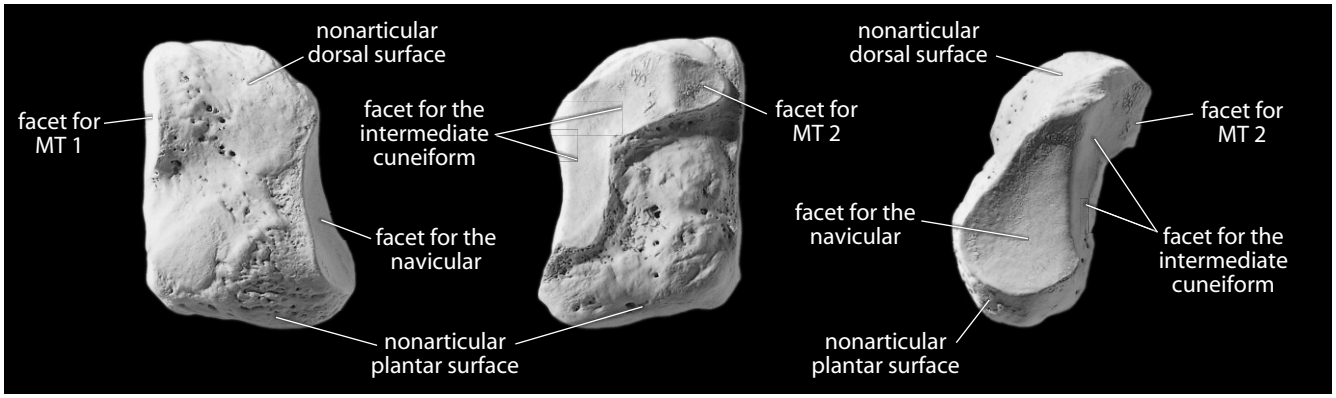

Figure 13.14 **Right medial (first) cuneiform.** *Left:* medial view; *middle:* lateral view; *right:* proximal view. Dorsal is up. Natural size.

13.1.6 Intermediate (Second) Cuneiform (Figure 13.15)

The intermediate cuneiform is the smallest of three cuneiforms. It is located between the navicular and the second metatarsal. In addition, it articulates on either side with the first and third cuneiforms.

- **Anatomical siding:** The nonarticular dorsal surface of the bone is broadest, and the bone wedges inferiorly, participating in the transverse arch of the foot. The proximal articular surface is usually the most concave (for the navicular). The lateral edge of this facet (proximal, lateral corner of the bone) is concave in profile. The lateral facet can be double or bilobate.
- **Positional siding:** Place the flat, nonarticular surface up and the concave facet away from you. The outline of the superior (dorsal) surface is a square whose most projecting corner points towards the side from which the bone comes.

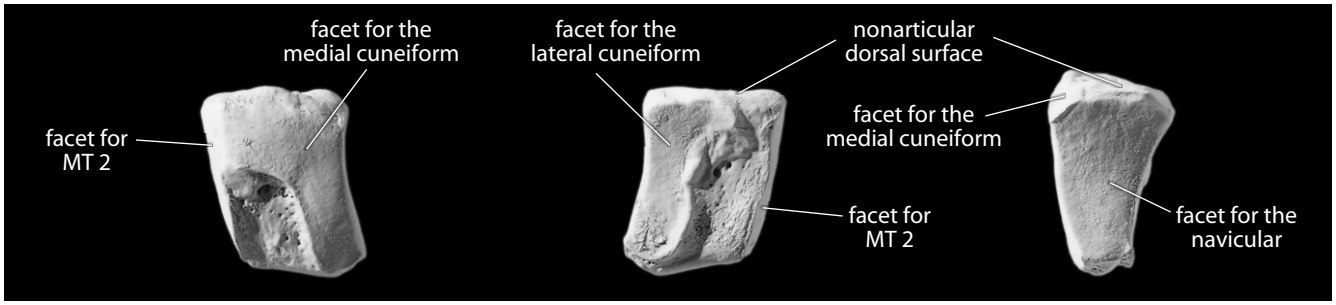

Figure 13.15 **Right intermediate (second) cuneiform.** *Left:* medial view; *middle:* lateral view; *right:* proximal view. Dorsal is up. Natural size.

13.1.7 Lateral (Third) Cuneiform (Figure 13.16)

The lateral cuneiform is intermediate in size between the other cuneiforms. It is located in the center of the foot, articulating distally with the second, third, and fourth metatarsals. Medially it contacts the intermediate cuneiform, laterally the cuboid, and proximally the navicular.

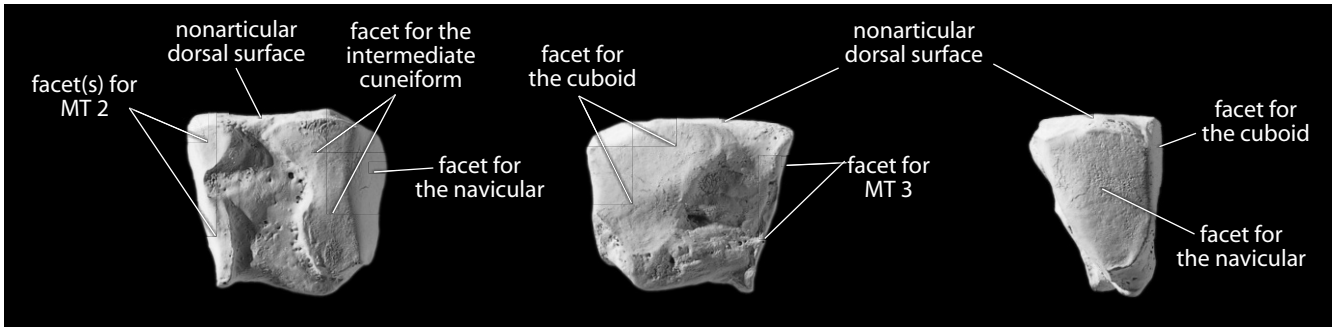

Figure 13.16 **Right lateral (third) cuneiform.** *Left:* medial view; *middle:* lateral view; *right:* proximal view. Dorsal is up. Natural size.

- **Anatomical siding:** The dorsal surface is a rectangular, nonarticular platform, and the bone wedges inferiorly to this. The proximal (navicular) articulation is wider but smaller than the elongate, wedge-shaped distal MT 3 facet. The border between the navicular and the cuboid facets projects in a V-shape as the base of the third cuneiform wedges between these two bones.
- **Positional siding:** Place the flat, nonarticular surface up (wedge down), with the smaller end facet toward you. The Africa-shaped facet is away from you. The longest boundary of the upper surface is on the side from which the bone comes.

13.1.8 Growth

The tarsals each ossify from a single center, with the exception of the calcaneus, which has an epiphysis at its posterior end.

13.1.9 Possible Confusion

As with the carpals, most of the tarsals are compact and robust structures. Identification of fragmentary tarsals is therefore not usually required. The exception to this is the calcaneus, which is less dense and is often broken in its nonarticular areas. Because most of the tarsals are larger than carpals, they are more often recovered from archaeological contexts. Siding of tarsals, as with carpals, is facilitated by positional techniques. Some of the techniques presented here are adopted from Bass (2005).

13.1.10 Tarsal Measurements (Figure 13.17)

The largest two tarsals, the talus and calcaneus, are the most often measured, and the measurements most often taken are indicated here (there are many others that have been defined and employed, depending on the particular research question being asked).

1. **Maximum calcaneal length** (Martin, 1928: 1058, #1; Buikstra and Ubelaker, 1994: 84, #77): Keeping the measuring axis of the sliding caliper parallel to the long axis of the bone, measure the greatest anteroposterior distance on the calcaneus.
2. **Posterior calcaneal length** (Martin, 1928: 1059, #5): Use a sliding caliper to measure the distance between the posteriormost point on the tuberosity and the anteriormost point on the posterior talar facet.

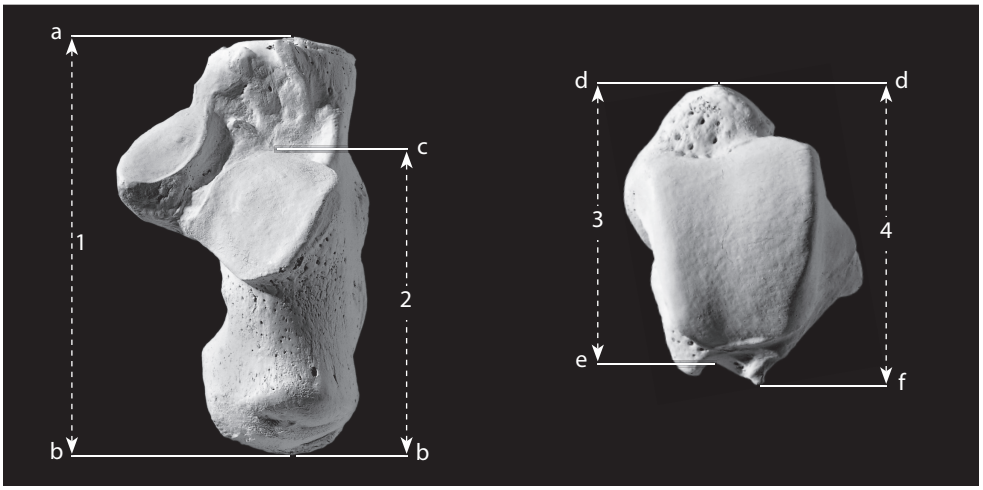

Figure 13.17 **Tarsal measurements.** Two-thirds natural size.

Locations: a) anteriormost point on calcaneus; b) posteriormost point on calcaneus; c) anteriormost point on the posterior talar facet; d) anteriormost point on talar head; e) deepest point in sulcus for *flexor hallucis longus*; f) posteriormost point on talus.

Measurements: 1) maximum calcaneal length; 2) posterior calcaneal length; 3) talar length; 4) maximum talar length.

3. **Talar length** (Martin, 1928: 1053–1054, #1; Steele, 1976: 582): With a sliding caliper, measure the distance between the sulcus for *flexor hallucis longus* and the anteriormost point on the talar head.
4. **Maximum talar length** (Martin, 1928: 1054, #1a): Similar to talar length, but is instead measured between the anteriormost point on the talar head and the posteriormost point on the talus (usually the posterior tubercle).

13.1.11 Tarsal Nonmetric Traits

- **Talar squatting facet(s)**: In individuals who habitually spend time with their ankles in a extreme dorsiflexed position (*e.g.,* sitting in a deep squatting position), a pair of conforming facets sometimes forms on the approximated anteroinferior tibia and anterosuperior talus. The talar facet is usually scored as 0 (absent), 1 (medial facet), 2 (lateral facet), 3 (central [neck] facet), 4 (medial and lateral facet), 5 (medial and neck facet), or 6 (lateral and neck facet).
- **Trochlear** (or **talar**) **extension(s)**: Using an imaginary line drawn in a paracoronal plane and intersecting the anterosuperior margin of the lateral malleolar surface of the talus as a reference, observe the medial and/or lateral talar trochlear margins extend anteriorly beyond this line. Usually scored as 0 (absent), 1 (medial extension), 2 (lateral extension), or 3 (medial and lateral extension).
- **Anterior calcaneal facet**: Occasionally the anterior and medial subtalar (or calcaneal) facets of the talus are discontinuous, either completely or partially separated by a nonarticular zone. Usually scored as 1 (one facet), 2 (two facets), or 3 (waisted or hour-glass facet).
- **Fibular** (previously **peroneal**) **tubercle**: Sometimes the fibular tubercle is present, sometimes it is absent, and sometimes it is indistinguishable from the attachment area of the calcaneofibular ligament. When the fibular tubercle can be clearly defined, it is scored as present. Usually scored as 0 (absent), or 1 (present).

13.2 Metatarsals (Figures 13.18–13.22)

The metatarsals, like the metacarpals, are numbered from MT 1 (the hallux, or big toe) through MT 5, according to the five rays of the foot. They are all tubular bones with round distal articular surfaces (**heads**) and more squarish proximal ends (**bases**). As with metacarpals, metatarsals are identified and sided most effectively according to the morphology of their bases.

The plantar metatarsal **shaft** surfaces are always more concave in lateral view than their dorsal shaft surfaces. The bases of nonhallucial metatarsals all articulate with adjacent metatarsals. Each of the tarsals in the distal row articulate with at least one metatarsal base.

13.2.1 First Metatarsal

The first metatarsal is the shortest but most massive metatarsal. It articulates at its base with the medial cuneiform. The **sesamoid grooves** at the base of the head correspond to sesamoid bones (Figure 13.25) in the *tendons of flexor hallucis brevis*, a short plantarflexor of the big toe.

- **Siding:** The basal facet has a convex medial profile and a straight lateral profile.

13.2.2 Second Metatarsal

The second metatarsal is the longest and narrowest metatarsal. It has two lateral facets at the base, each articulating with the lateral cuneiform and MT 3. It articulates proximally with the intermediate cuneiform and medially with the medial cuneiform. Its base has slightly more of a "styloid" appearance than the base of MT 3.

- **Siding:** The most proximal point on the base is lateral to the main shaft axis.

13.2.3 Third Metatarsal

The third metatarsal is very similar to MT 2, but its base has two medial basal facets that are smaller than MT 2 lateral facets. The lateral basal facet is single and large. The base is squarer than the MT 2 base, and there is a large, bulging tubercle distal to the lateral articular facet. The base articulates with MT 2 and MT 4 and with the lateral cuneiform.

- **Siding:** The most proximal point on the base is lateral to the main shaft axis.

13.2.4 Fourth Metatarsal

The fourth metatarsal is shorter than MT 2 or MT 3. It has single medial and lateral basal facets for articulation with MT 3 and MT 5. The proximal facet for the cuboid is fairly oval.

- **Siding:** The most proximal point on the base is lateral to the main shaft axis.

13.2.5 Fifth Metatarsal

The fifth metatarsal bears a large **styloid process**, a distinctive, blunt, nonarticular basal projection. It is lateral, opposite the MT 4 facet, and projects proximally. It is the insertion point for the *tendon of the fibularis (peroneus) brevis muscle*, a calf muscle that acts to plantarflex and evert the foot

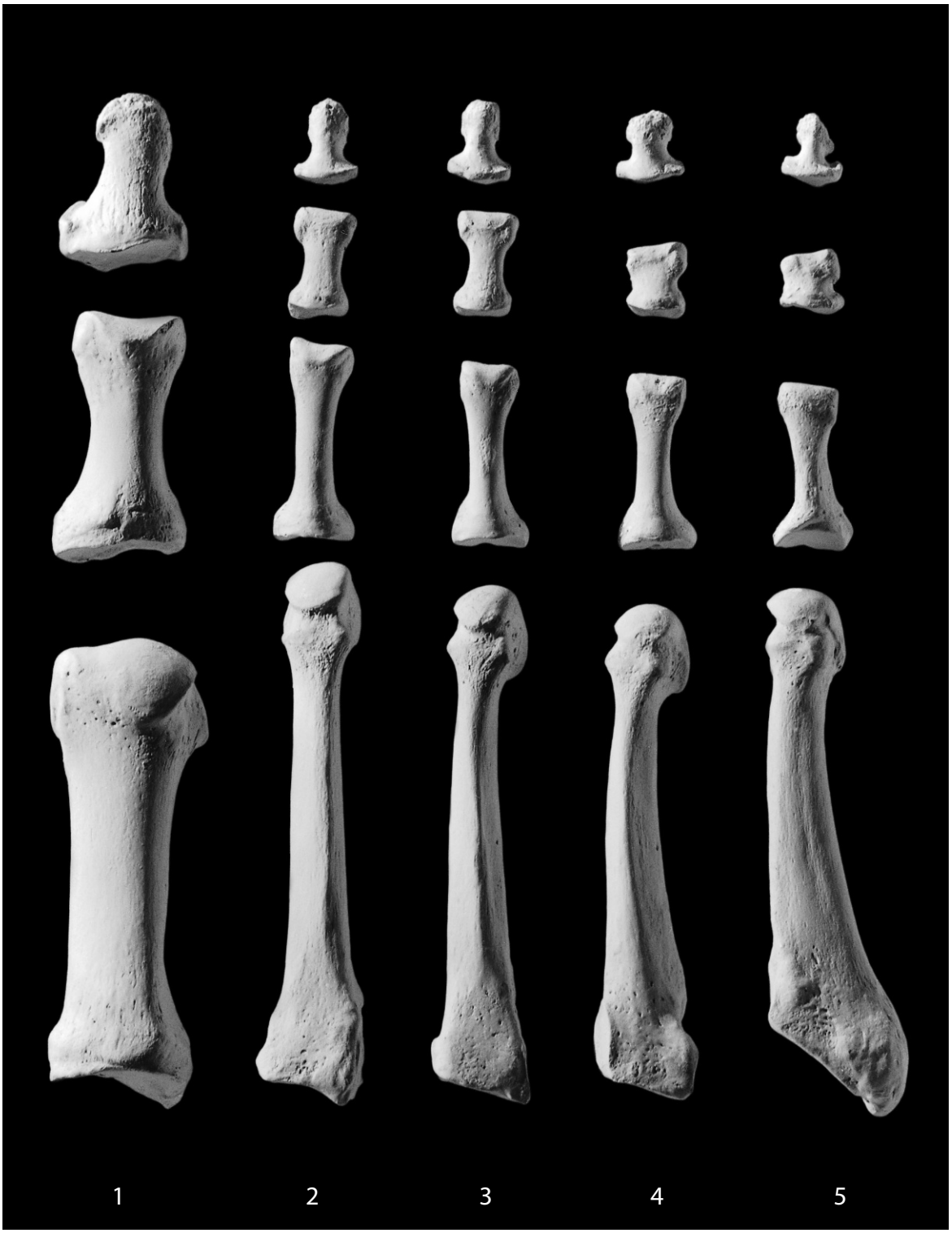

Figure 13.18 **Right foot, dorsal (superior).** Rays 1–5, showing the metatarsals and the proximal, intermediate, and distal foot phalanges. Distal is up; lateral is toward the right. Natural size.

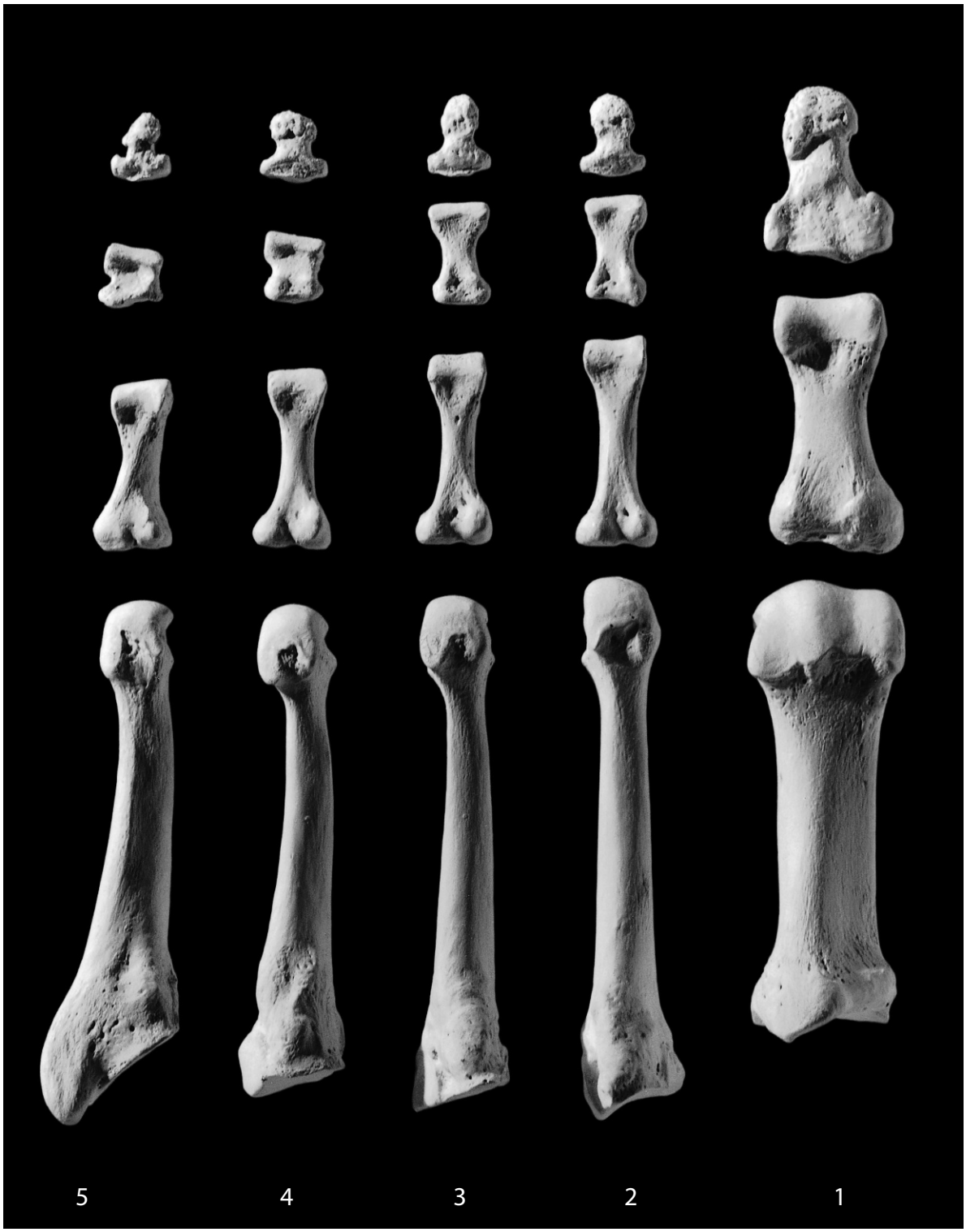

Figure 13.19 **Right foot, plantar (inferior).** Rays 1–5, showing the metatarsals and the proximal, intermediate, and distal foot phalanges. Distal is up; lateral is toward the left. Natural size.

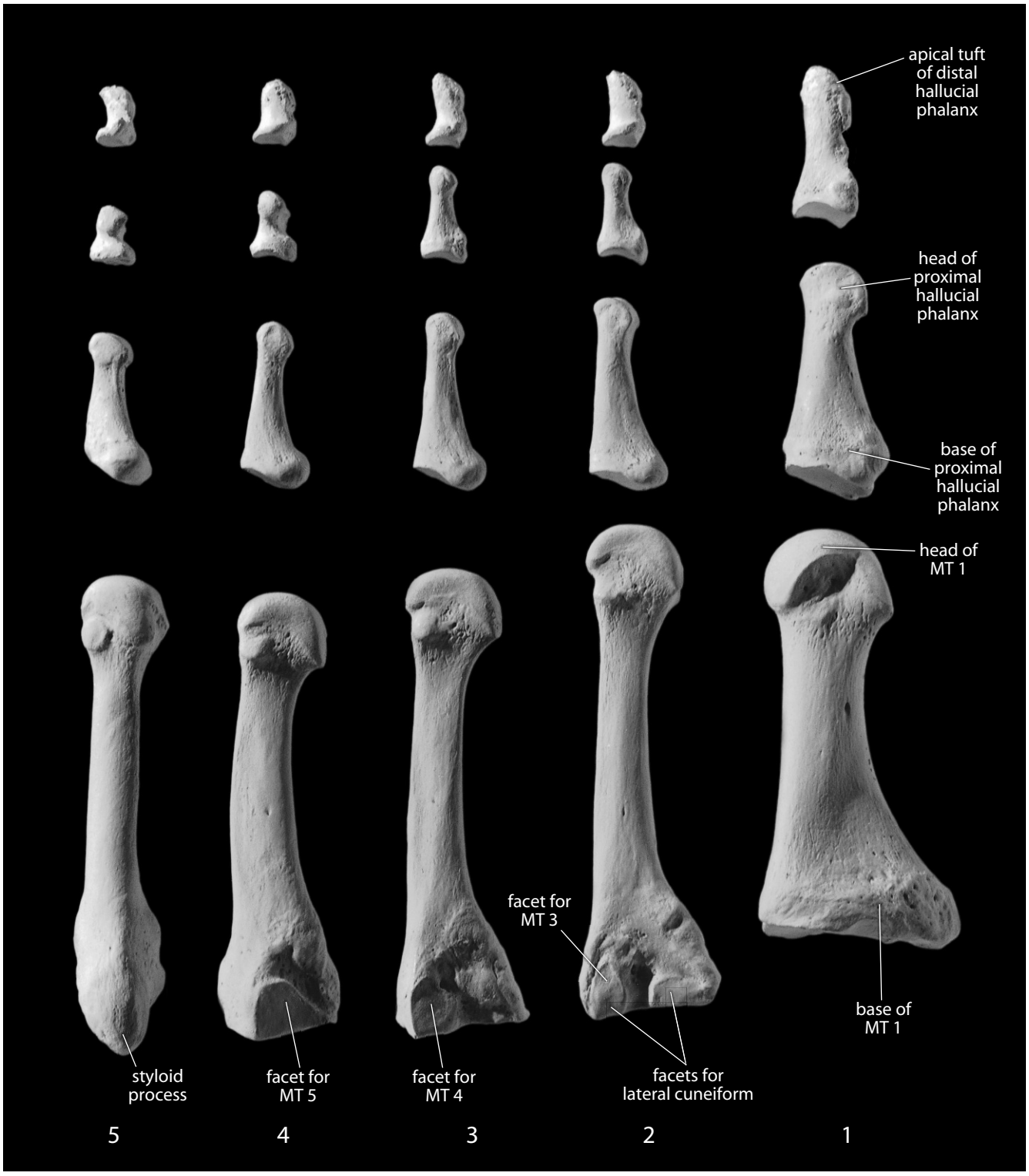

Figure 13.20 **Right foot, lateral.** Rays 1–5, showing the metatarsals and the proximal, intermediate, and distal foot phalanges. Distal is up; plantar is toward the right. Natural size.

at the ankle. On the plantar side of the styloid process is a groove marking the route of the *flexor digiti minimi muscle*. The proximal basal articulation is for the cuboid.

- **Siding:** The styloid process is lateral. Groove on the base of the tubercle is inferior.

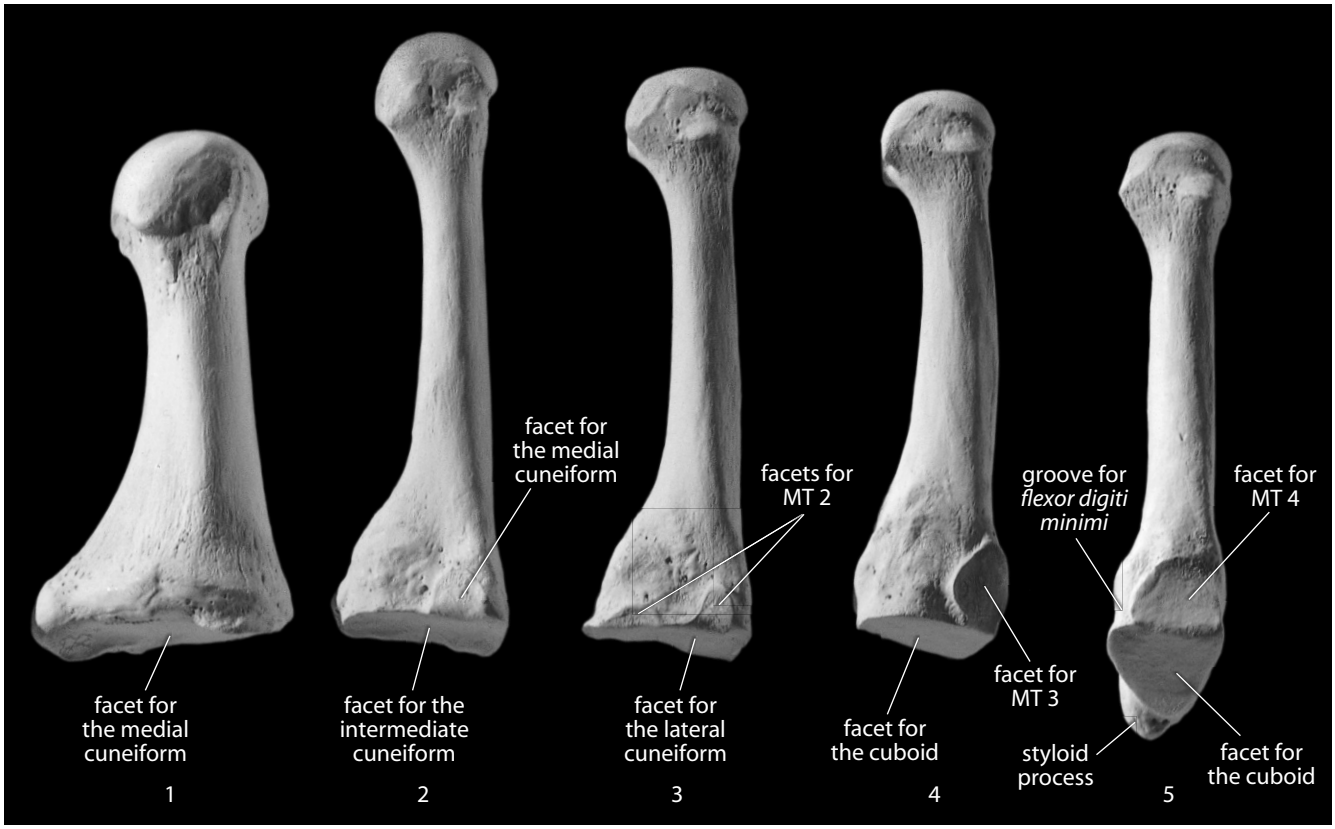

Figure 13.21 **Right metatarsals, medial.** Distal is up. Natural size.

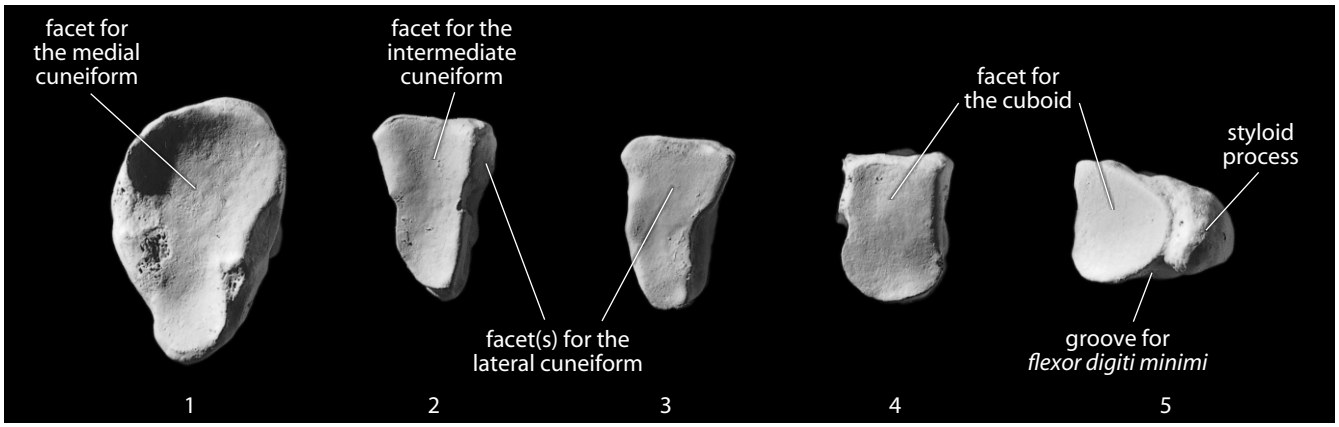

Figure 13.22 **Right metatarsal bases, proximal.** Dorsal is up. Natural size.

13.2.6 Growth (Figure 13.23)

Metatarsals each ossify from two centers. For MT 2, MT 3, MT 4, and MT 5 there is one center for both the base and shaft and a second for the distal end. For the MT 1, there is one center for the shaft and one for the proximal end.

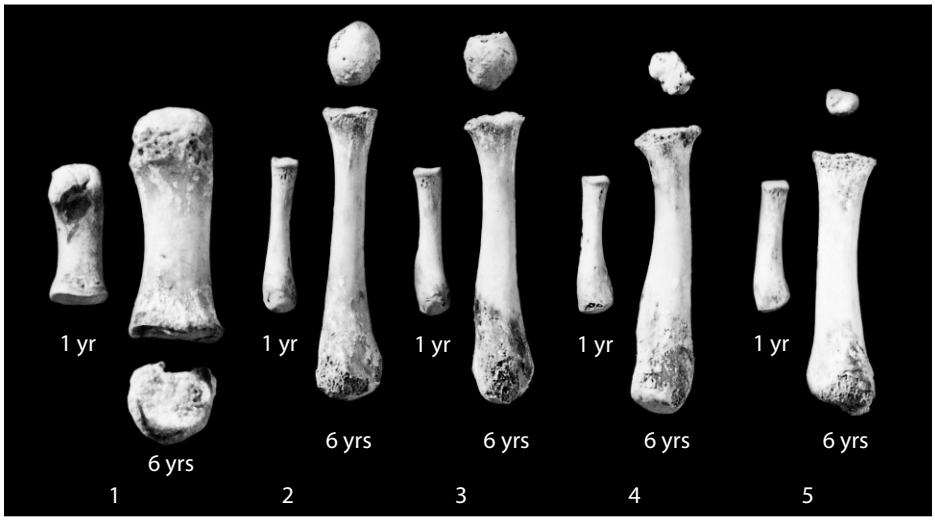

Figure 13.23 **Metatarsal growth**. The pairs of immature metatarsals are shown here in plantar view, with ray 1 on the left and ray 5 on the right. They are from one-year-old and six-year-old individuals. Natural size.

13.2.7 Possible Confusion

Metatarsals and metacarpals are similar in gross size and shape but are easily distinguished from each other. Metatarsals 2, MT 3, MT 4, and MT 5 are longer than metacarpals 2, MC 3, MC 4, and MC 5, with straighter and narrower shafts. Metatarsal heads are compressed more mediolaterally and are smaller relative to their bases than metacarpal heads.

13.2.8 Siding

Metatarsal bases are always proximal, and the most proximal part of the base is always lateral on MT 2, MT 3, MT 4, and MT 5.

13.2.9 Metatarsal Measurements (Figure 13.24)

1. **Maximum metatarsal length** (Cordeiro et al., 2009: 131.e2; Zipfel et al., 2009: 534, #2): Keeping the sliding caliper parallel to the long axis of the diaphysis, determine the maximum length of the metatarsal.
2. **Metatarsal biomechanical** (or **articular**) **length** (Martin, 1928: 1064, #1 [for MT 1], #2 [for MT 2–5]): With a sliding caliper (or for MT1, a small spreading caliper or a sliding caliper equipped with at least one inside point extension), measure the distance from the center of the tarsal articular surface to the distalmost point on the metatarsal head.
3. **Midshaft height** (Martin, 1928: 1064, #4): First, determine the location at midshaft using 50% of biomechanical length. At this location, use a sliding caliper to measure the greatest dorsoplantar dimension.
4. **Midshaft breadth** (Martin, 1928: 1064, #3): Measuring from the midshaft location (50% of biomechanical length), use a sliding caliper to measure the greatest mediolateral dimension.

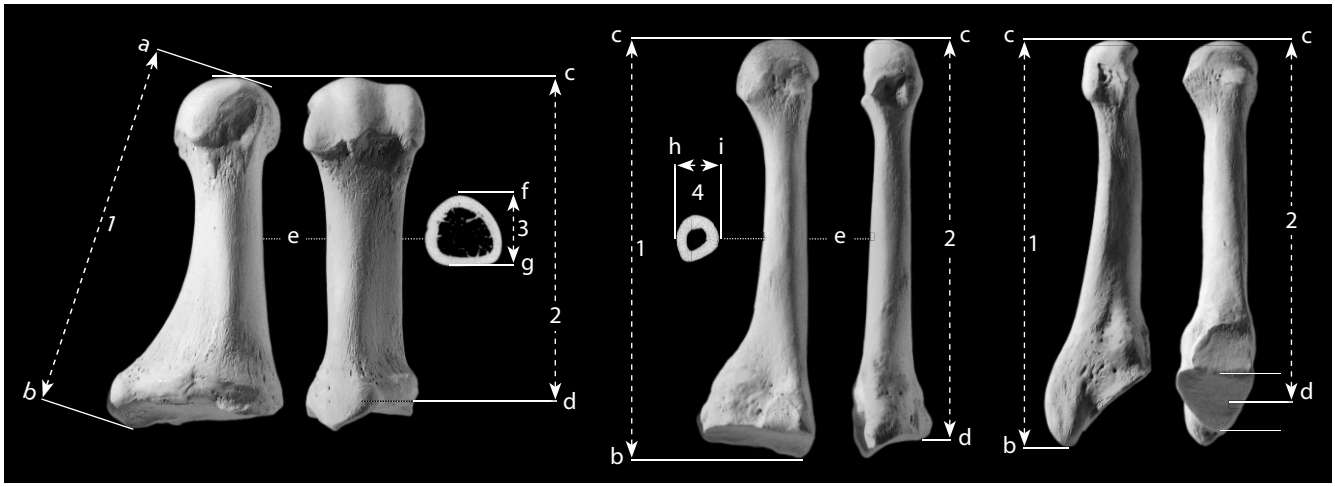

Figure 13.24 **Metatarsal measurements.** Distal is up for bones; for scans, plantar is up. Two-thirds natural size.

Locations: a) point on metatarsal head farthest from 'b'; b) proximalmost point on metatarsal; c) distalmost point on metatarsal head; d) center of tarsal articular surface; e) location of midshaft; f) plantarmost point at midshaft; g) dorsalmost point at midshaft; h) lateralmost point at midshaft; i) medialmost point at midshaft.

Measurements: 1) maximum metatarsal length; 2) metatarsal biomechanical (or articular) length; 3) metatarsal midshaft height; 4) metatarsal midshaft breadth.

13.2.10 Metatarsal Nonmetric Traits

- There are no commonly cited nonmetric traits of the metatarsals, and variation in discrete traits seen in these elements is rarely noted.

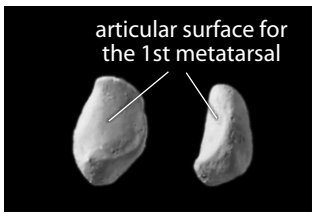

Figure 13.25 **Sesamoid of the right foot.** *Left:* superior (or dorsal) view; *right:* lateral view. Natural size.

13.3 Foot Phalanges (Figures 13.18–13.20, 13.26–13.27)

Foot phalanges are all shorter than metatarsals, and they lack the rounded heads of metatarsals. The hallucial (big toe) phalanges are shorter and squatter than the others, and the hallux lacks an intermediate phalanx. The expanded proximal end of each phalanx is the **base**. The distal end is the **head** (in proximal or intermediate phalanges) or the **distal tip** (or tuft; in the distal phalanges). The distal articular surface of proximal and intermediate phalanges is called the **trochlea.** Unlike hand phalanges, both dorsal and plantar surfaces of foot phalanges are smooth and rounded. Foot phalanges are much shorter than hand phalanges in humans.

13.3.1 Proximal Foot Phalanges

Each proximal foot phalanx displays a single, concave proximal facet for the metatarsal head, and a spool-shaped, or trochlear, surface distally. The hallucial proximal phalanx is larger and stouter than the others.

13.3.2 Intermediate Foot Phalanges

Each intermediate foot phalanx displays a double proximal articular facet for the head of the proximal phalanx. Each also has a trochlear distal articular facet. These phalanges are "stunted," squat versions of their analogs in the hand.

13.3.3 Distal Foot Phalanges

Each distal foot phalanx displays a double proximal articular facet for the head of the intermediate phalanx, but the terminal tip of the bone is a nonarticular pad, the **distal phalangeal tubercle** (or **tuft**). These distal foot phalanges are very small and stubby compared to distal hand phalanges.

13.3.4 Growth (Figure 13.23)

Foot phalanges each ossify from two centers: one for the shaft and distal end, and one for the base.

13.3.5 Possible Confusion

Hand and foot phalanges are easily distinguished, even when isolated. Foot phalanges are all much shorter than their analogs in the hand.

- Proximal foot phalanges are the only ones that might be mistaken for hand phalanges.
- Phalangeal shafts in the hand are compressed dorsoventrally, forming a D-shape in cross section, whereas those in the foot are more circular in cross section (Figure 13.27). Therefore, the shafts of foot phalanges will roll easily between your fingertips, and the shafts of hand phalanges will not.
- Foot phalanges display more constriction at midshaft than hand phalanges.
- The hallux has only a proximal and a morphologically distal phalanx, and these squat, massive bones are very distinctive.

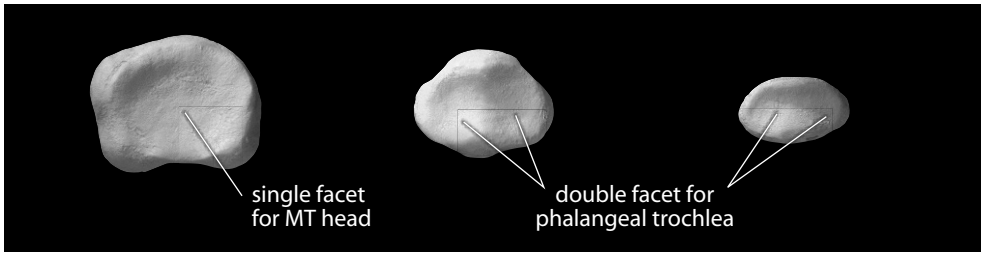

Figure 13.26 **Bases of foot phalanges.** *Left:* proximal foot phalanx; *center*: intermediate foot phalanx; *right:* distal (or terminal) foot phalanx. All phalanges are from ray 2. Dorsal is up. Natural size.

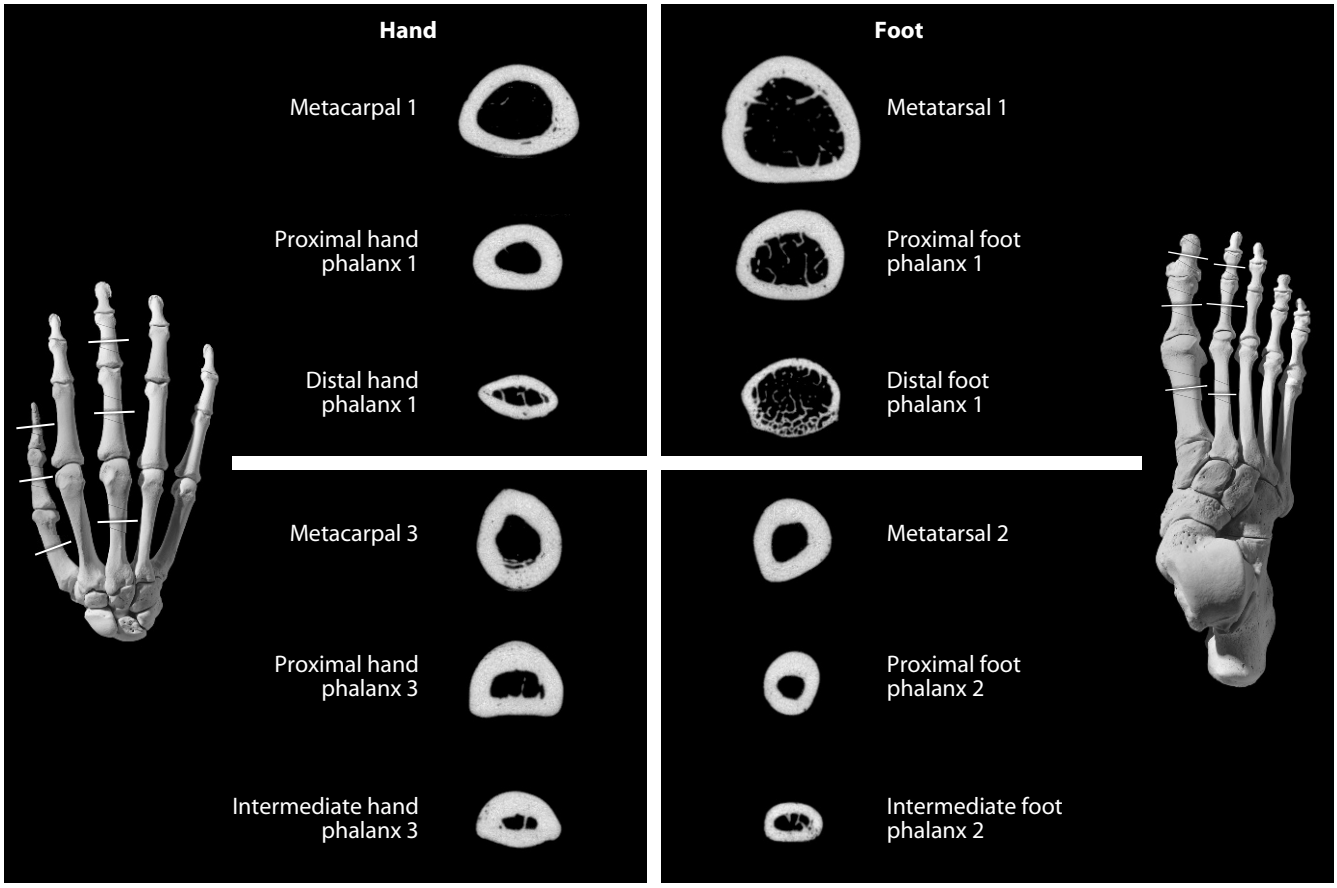

Figure 13.27 **Midshaft CT scans of long bones of the foot and hand compared.** Shafts of foot phalanges and the hallucial metatarsal have rounder cross sections than those of hand phalanges or the thumb metacarpal. The scans were taken from the bones of the individual used to illustrate postcrania in this book. The positions of the CT sections are illustrated on the articulated hand and foot. Dorsal is up and palmar/plantar is down. Natural size.

13.3.6 Siding

It is best to work with whole specimens and comparative materials for siding hand and foot phalanges. The head is distal, and the base is proximal. The dorsal phalangeal shaft surfaces are smooth and straight, whereas the plantar surfaces are more irregular and curved.

13.3.7 Pedal Phalangeal Measurements (Figure 13.28)

1. **Phalangeal length** (Martin, 1928: 1065, #1): Keeping the sliding caliper parallel to the long axis of the phalangeal diaphysis, determine the maximum distance between the distal trochlea or tuft to the proximalmost point on the plantar surface of the phalanx.
2. **Phalangeal biomechanical** (or **articular**) **length** (Martin, 1928: 1065, #1a): With a small spreading caliper or a sliding caliper equipped with at least one inside point extension, place the point extension in the depth of the middle of the proximal articular surface and measure the distance to either the proximalmost point on the head of the phalanx (for proximal and intermediate phalanges) or to the distalmost point on the apical tuft (for distal phalanges).

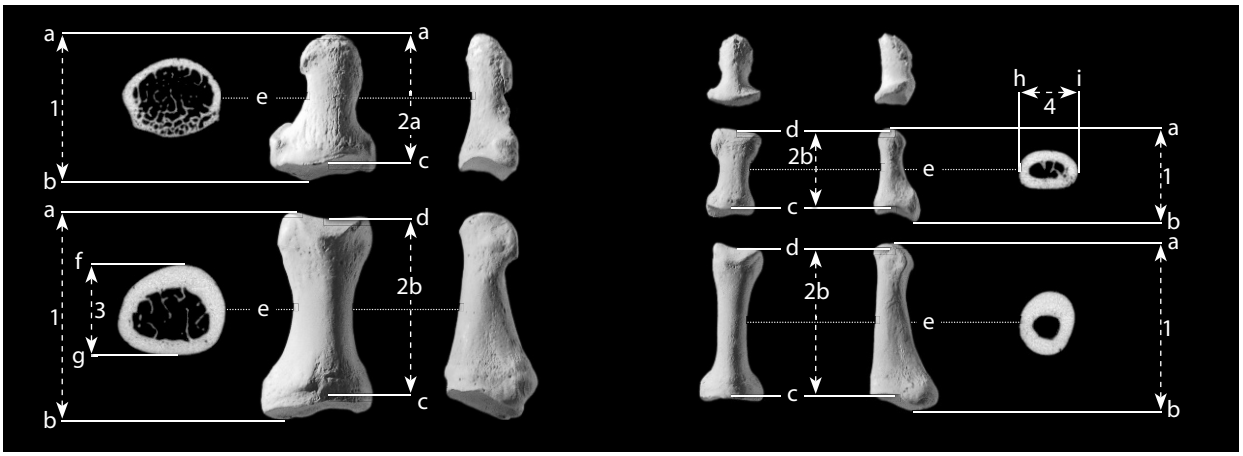

Figure 13.28 **Foot phalangeal measurements.** Phalanges of first and second pedal ray. Distal is up for bones; for scans, dorsal is up. Natural size (CT sections) and two-thirds natural size (bones).

Locations: a) distalmost point on phalanx; b) proximalmost point on phalanx; c) deepest point of proximal articular surface; d) distalmost point of central sulcus of trochlea; e) location of midshaft; f) dorsalmost point of midshaft; g) plantarmost point of midshaft; h) medialmost point of midshaft; i) lateralmost point of midshaft.

Measurements: 1) phalangeal length; 2a) phalangeal biomechanical length (of distal phalanx); 2b) phalangeal biomechanical length (of proximal or intermediate phalanx); 3) phalangeal midshaft height; 4) phalangeal midshaft breadth.

3. **Midshaft anteroposterior** (or **dorsoplantar**) **height** (Martin, 1928: 1065, #3): First, determine the location at midshaft using 50% of biomechanical length. At this location, use a sliding caliper to measure the greatest dorsoplantar dimension.
4. **Midshaft mediolateral breadth** (Martin, 1928: 1065, #2): Measuring from the midshaft location (50% of biomechanical length), use a sliding caliper to measure the greatest mediolateral dimension.

13.3.8 Pedal Phalangeal Nonmetric Traits

- There are no commonly cited nonmetric traits of the foot phalanges, and variation in these elements is rarely specifically categorized as discrete traits.

13.4 Functional Aspects of the Foot

The rigid, transversely and longitudinally arched form of the human foot is a radical departure from the grasping appendage that characterizes the other living primates. Hominid anatomy evolved to meet the peculiar demands of habitual, striding, bipedal locomotion. Cartmill, Hylander, and Shafland (1987) note that anatomy of the human foot is best appreciated by considering it as a hand in which the thumb is tied to the second digit, the metacarpals elongated to form a longer lever, the phalanges shortened, and the serial homolog of the triquetral (the foot's calcaneus) enlarged into a massive lever arm. Foot phalanges have fingerlike movements, but these are comparatively restricted. Extrinsic foot muscles in the foreleg, like those of the forearm, move the foot and toes. These are compartmentalized, with plantar flexors posteriorly and dorsiflexors anterolaterally. These muscles operate mostly via tendons across the ankle. As in the hand, there are also intrinsic foot muscles.